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DIAGNOSTIC ULTRASOUND DEVICE WITH AN ACOUSTIC OPERATING UNIT
[Diagnostisches Ultraschallgerät mit einer Akustikbedieneinhet]

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SPECIFICATIONS

A diagnostic ultrasound device with an acoustic operating unit.

The invention relates to a diagnostic ultrasound device with an operating unit by means of which the operating states of the ultrasound device can be set manually and which produces operating signals from the set operating states, and with a control, connected to the operating unit, that uses the operating state signals to produce control signals for the ultrasound signal.

The screen display of parts of the human anatomy using ultrasound has become essential to medical diagnostics. Diagnostic ultrasound devices offer a number of possibilities for examination that are characterized by different operating states, depending on the medical problem in question. In addition, various parameters can be set in the device in order to obtain an optimal image. The operating states also include various image types, such a A-, B-, and M-mode and combinations thereof. Normal commercial ultrasound devices have an operating unit for presetting parameters and operating states that comprises a keypad or a console. Special examinations, such as examination of the lower extremities, are facilitated by remote control of the operating state that is wireless or that is connected to the device by a cable. The remote control can be used, for

example, to control the image, the size of the field of vision, the magnification, and the activation of a video printer or image storage. A footswitch consisting, for example, of two pedals is also provided to further facilitate operation, particularly during difficult examinations. The first pedal, for example, activates the image storage, while the function of the second pedal is freely selectable.

Diagnostic ultrasound devices are now being used increasingly for imaging during interventional (e.g., biopsies) and invasive (e.g., surgical) procedures. In intraoperative use, the problem is that the device is generally not sterile, so that operating must be taken over by an additional person located in a nonsterile area. During intraluminar ultrasound examinations the examiner generally does not have a hand free for operating the ultrasound device. A similar situation is found during the ultrasound-assisted implantation of radioactive sees for treating prostate cancer. In this case, the possible operating options offered by the footswitch are generally insufficient.

It is the object of this invention to present an ultrasound device whose operating states can be set by a user in a contactless manner.

This object is achieved in that an acoustic operating unit is connected to a control that produces operating-state signals from acoustic signals, apart from the operating unit. Control of the operating states by means of an acoustic operating unit permits the examiner to concentrate completely on the examination, without being distracted by operation of the ultrasound device. Moreover, during difficult stages of the examination or ultrasound-assisted operations, he can use both hands and still change the operating state of the ultrasound device used during the examination. Ultrasound devices with an acoustic operating unit can be used, in particular, in surgery, during examinations with an ultrasound catheter, and during an ultrasound-assisted implantation or biopsy.

One advantageous embodiment is characterized in that the acoustic operating unit has a command storage with storage space for a maximum of 30 different data records, whereby a data record represents an acoustic signal. By limiting the options to a relatively small number of acoustically clearly distinguishable signals or commands, signal recognition is highly reliable, so that operation of the ultrasound device is also highly reliable.

An additional advantageous embodiment is characterized in that the acoustic operating unit contains a speech synthesizer that

confirms the acoustic signal that is recognized as a command. This verbal confirmation also increases the reliability of the operating unit.

An additional advantageous embodiment is characterized in that the acoustic operating unit contains a wireless microphone. In this way, the user is not limited in his freedom of motion by a cable connection.

Two embodiments of the invention will be explained below with the help of the 2 figures. They show:

Figure 1: an acoustic operating unit that is connected by way of an interface to an ultrasound device and

Figure 2: an acoustic operating unit with a wireless microphone that is integrated into an ultrasound device.

The acoustic operating unit controls a conventional ultrasound device **2**. In Fig. 1, ultrasound device **2** is shown as in block diagram form. Ultrasound device **2** has an ultrasound applicator **4** that is connected to a transmit-receive unit **6**. Transmit-receive unit **6** produces transmit signals that are radiated as an ultrasound wave into an examination region. Echo signals received from the examination region are converted into electrical signals in ultrasound applicator **4** and further processed by transmit-receive unit **6**. Transmit-receive

unit **6** is connected to a signal-processing unit **8**, which converts the received echo signals to image signals for display on monitor **10**. Operating states of ultrasound device **2** can be manually set using operating unit **12** which contains, for example, a console with a keypad, function switches, and adjustment controls, for example, for depth-dependent amplification. Operating unit **12** produces operating-state signals from the preset operating states. These operating-state signals are fed as input signals into a control unit **14** connected to operating unit **12**. Control unit **14** converts the operating-state signals into control signals, which act on transmit-receive unit **6**, signal-processing unit **8**, and monitor **10**. Operating unit **12** can also include an infrared remote control, not shown here, with which selected operating states can be set. It is also possible to set one or two operating states using footswitches, also not shown here, in parallel with operating unit **12**.

Important settings for ultrasound device **2** that can be set manually using operating unit **12** include, for example:

-Slide controls that set the amplification of a depth-compensation amplifier for various depths, whereby the settings for various applicator types can be stored;

-Echo filter and image correlation in several stages;

-Dynamic range setting;

-Gray-scale compression;

-Image modes, e.g., A-, B-, M-mode and combinations;

-Scanning thickness setting;

-Enlargement of a presettable image window;

-Selection of the time axis in M-mode;

-Image reversal right/left or top/bottom;

-Image position;

-Black/white reversal for negative image;

-Image storage;

-etc.

Using an acoustic operating unit **20**, selected operating states can be set in a contactless manner with acoustic signals. Acoustic operating unit **20** includes a microphone **22**, which is connected to the input of an adjustable threshold amplifier **24**.

The threshold of threshold amplifier **24** is adjustable using potentiometer **26** and this tunes out background noise. Background noise can also be tuned out by a suitable circuit that uses a low-pass filter with a large time constant (up to several seconds) at the mean value of the noise. This mean value forms the threshold value. Thus,

the signal taken from microphone **22** must be at a minimum level if it is to be processed further. A signal-matching unit **28** is connected to the output of amplifier **24**. It converts characteristic properties of the analog acoustic signal into digital information for a microprocessor **30**. The function of signal-matching unit **28** will be explained in greater detail below.

Connected to microprocessor **30** are operating elements **32**, with which the various operating states of acoustic operating unit **20** may be set. The main operating states of acoustic operating unit **20** are "Learn Command" and "Recognize Command." Display elements **34** are provided to inform the user of the operating states of acoustic operating unit **20**. Moreover, a command storage **36** is connected to microprocessor **30**. It is made in the form of a random access memory and it is capable of storing one or more user-specified command sets. Depending on the system used, a hard disk or a nonvolatile RAM card, for example, may be used for nonvolatile command storage **36**. A speech synthesizer **38**, also connected to microprocessor **30**, provides acoustic confirmation of a recognized command.

The recognized commands from microprocessor **30** are sent in the form of operating-state signals by way of interface **40** to ultrasound device **2**. Ultrasound device **2** has an interface **42** for this purpose,

which relays the commands it receives to control unit **14**.

Compared to other processes, the process described below for recognizing the acoustic signals as commands requires minimal hardware and software expenditures. One limitation on this speech recognition process, however, is that only a few--and acoustically distinct--different words or commands can be recognized.

For controlling ultrasound device **2**, it is sufficient to limit the number of operating states to a maximum of 30, i.e., 30 different commands. Selected operating states include, for example:

-Save image

-Real time

-Ultrasound frequency 1

-Ultrasound frequency 2

-Enlarge area 1

-Enlarge area 2

-Enlarge area 3

-End enlarge

-Hardcopy for the depth compensation amplifier

-Increase amplification

-Decrease amplification

-Scanning depth 1

-Scanning depth 2

-Scanning depth 3

-Stop change in amplification

The commands can be freely programmed by the user. If an attempt is made to enter two commands that are difficult to distinguish, then the second command is rejected by microprocessor **30** of acoustic operating unit **20** for safety reasons.

The acoustic signal received from the microphone is evaluated by signal-matching unit **28** only for the zero crossings and not for its amplitude. Thus, expensive amplitude standardizing of the acoustic signal is not required. The time between two zero crossings corresponds to the frequency. It is determined and coded as a binary number. Each command has a word that can be divided into 16 sections. In this way, the same amount of data is obtained for each word. Each section is frequency analyzed separately. By using this division into 16 sections of the same duration, it does not matter if a word is spoken at a different speed than that of the stored version. The number of the occurring frequencies per section is examined in order to obtain for each section a sequence of numbers that is relatively simple to compare to a reference pattern with little need for storage space. Thus, for each section all that is stored is how often, for

example, the frequency range 2 to 3.5 kHz appears. By limiting the frequency ranges to seven, each word section requires a storage space of 7x8 bits. The eighth frequency range is not used. Consequently, 128 W per word is stored.

Thus, acoustic operating unit **20** is capable of storing a command in the form of a frequency-incidence pattern. Since slight differences occur each time the same word is spoken, each word is entered for example four times during a learning phase that is set by operating elements **32** and an average pattern is stored as a data set that represents the acoustic signal.

In the "Recognize Command" mode a word or command spoken into microphone **22** is broken down into its frequency-incidence pattern and compared to all the reference pattern data sets. The command with the smallest mean-square error sum is considered recognized. An upper limit can be set on the mean-square error sum.

With the ultrasound device **2** in Fig. 2, an acoustic operating unit is integrated into the control unit of the ultrasound device. A central control unit **50** contains both the controls for the ultrasound device and the controls for the acoustic operating unit. Compared to the embodiment in Fig. 1, then, control unit **14** for the ultrasound device and microprocessor **30** for the acoustic operating unit are

combined. As a result, there is no need for interfaces **40** and **42**. In order not to burden the user with cable connections, wireless microphone **52** is provided that, apart from the actual microphone **22** such as a shoulder or throat microphone, also includes a microphone transmitter **54** A microphone receiver **56** is arranged on ultrasound device **2** and it is connected to amplifier **24** The remaining functional units correspond to the units previously described in conjunction with Fig. 1. The operating state of acoustic operating unit **20** is displayed on monitor **10**.

The operating safety of the ultrasound device can be increased by using a so-called decision tree. Based on the current operating state, a decision is made as to whether the recognized command is sensible and safe in this context. Additional safety can be achieved by a confirming query, e.g., speech synthesizer **38** can repeat the command and ask, for example, "Are you sure?" or something similar. The command is then carried out after recognition of the confirmation with "yes" or some other user-defined key word.

Claims

1. A diagnostic ultrasound device **2** with an operating unit **12** by means of which the operating states of the ultrasound device **2** can be set manually and which produces operating signals from the set

operating states, and with a control unit **14, 50** connected to operating unit **12**, that uses the operating state signals to produce control signals for ultrasound device **2**, **characterized in that** an acoustic operating unit **20** is connected to control unit **14, 50**, which produces operating-state signals from acoustic signals, apart from operating unit **12**.

2. A diagnostic ultrasound device as recited in Claim 1, characterized in that acoustic operating unit **20** is made in the form of a voice-control unit.

3. A diagnostic ultrasound device as recited in Claim 1 or 2, characterized in that acoustic operating unit **20** includes a command storage **36** with storage spaces for a maximum of 30 different data sets, whereby a data set represents an acoustic signal or command.

4. A diagnostic ultrasound device as recited in one of the Claims 1 through 3, characterized in that acoustic operating unit **20** contains a speech synthesizer **38** that verbally confirms the acoustic signal that has been recognized as a command.

5. A diagnostic ultrasound device as recited in one of the Claims 1 through 4, characterized in that acoustic operating unit **20** includes a wireless microphone **52**.

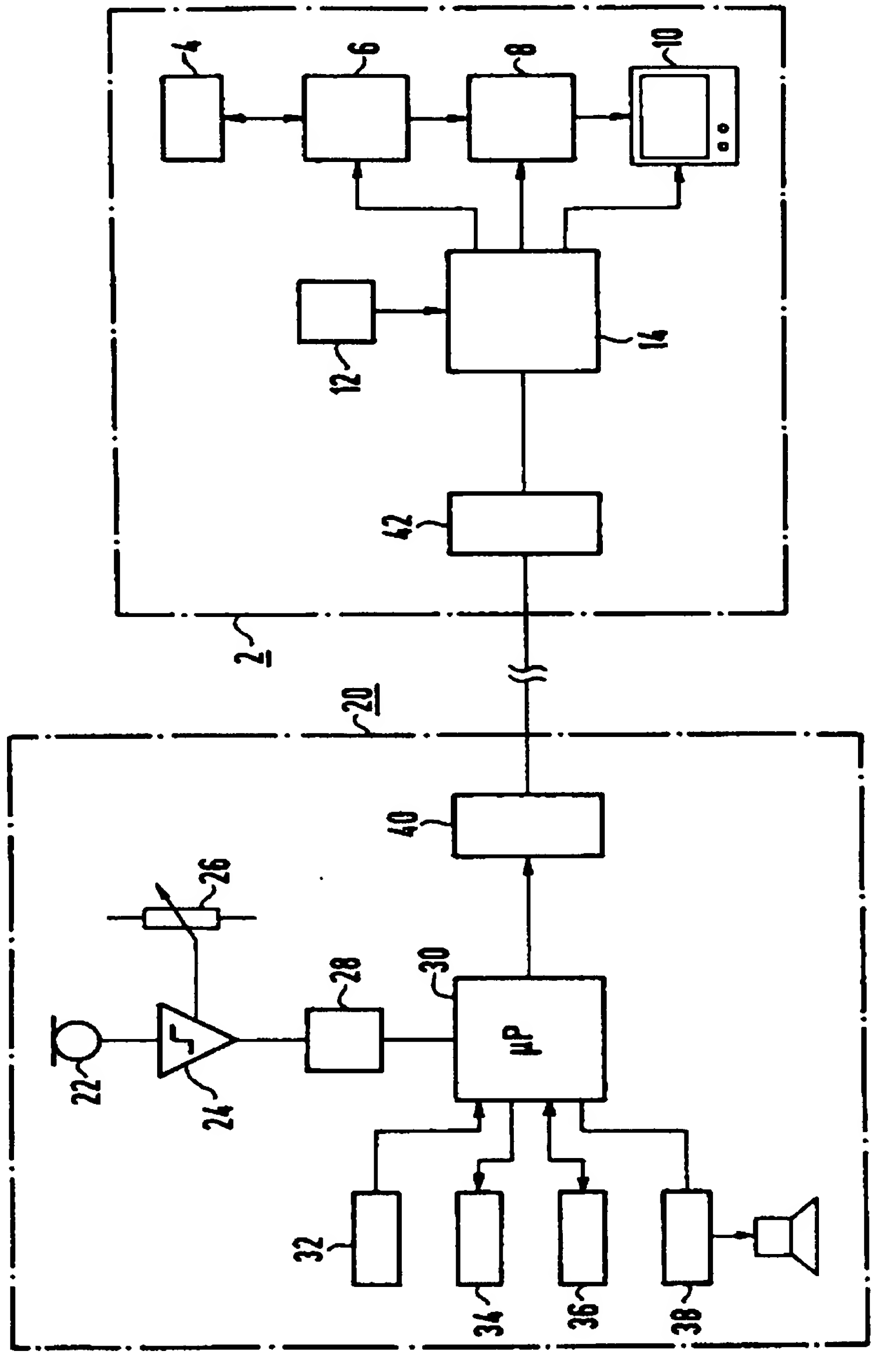

FIG 1

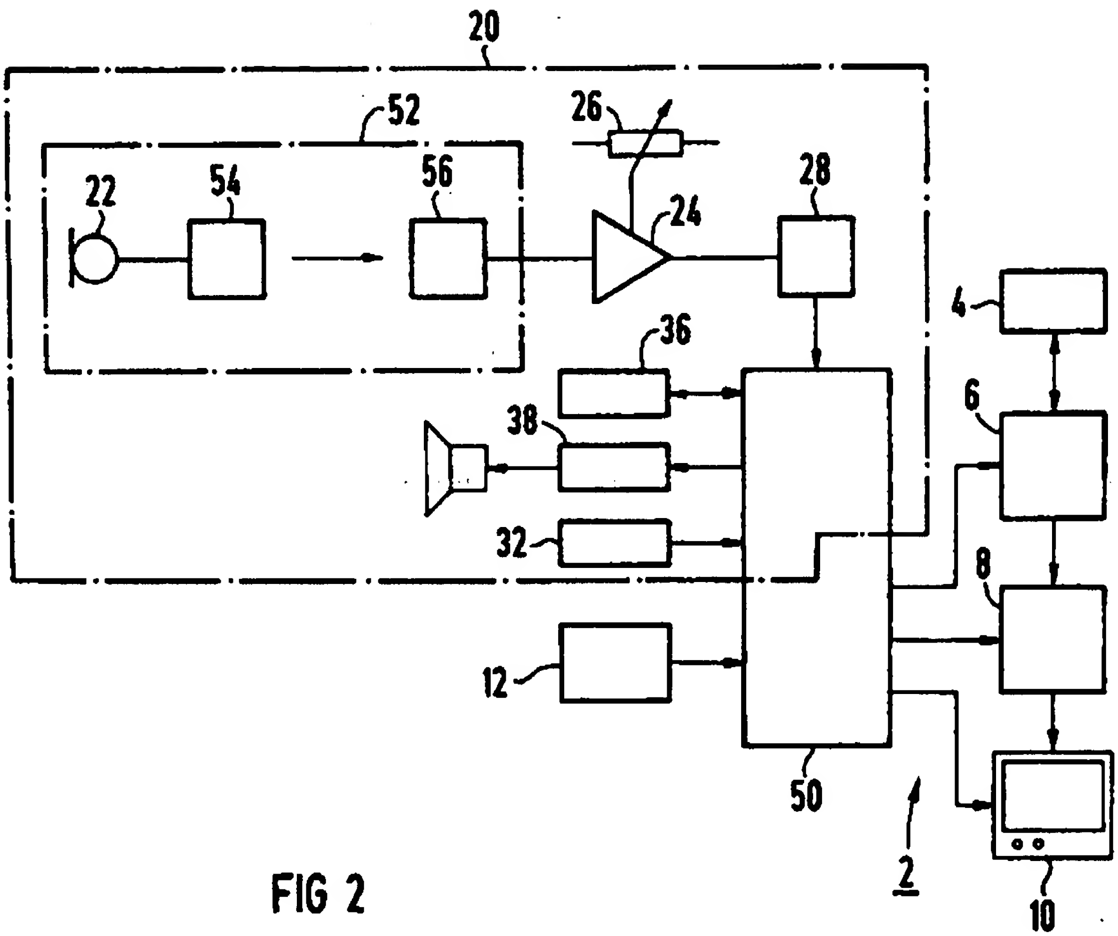

FIG 2